PMI Experiments and Modeling at the University of Illinois

David N. Ruzic

Robert Stubbers, Matt Coventry, Wes Olczak,
Travis Gray, Ben Masters, Huatan Qiu

Department of Nuclear, Plasma, and Radiological Engineering
University of Illinois
Urbana, IL USA

PLASMA MATERIAL
INTERACTION GROUP
University of Illinois at Urbana-Champaign

Outline

- Introduction
- Previous Results
- TDS in FLIRE – Robert Stubbers
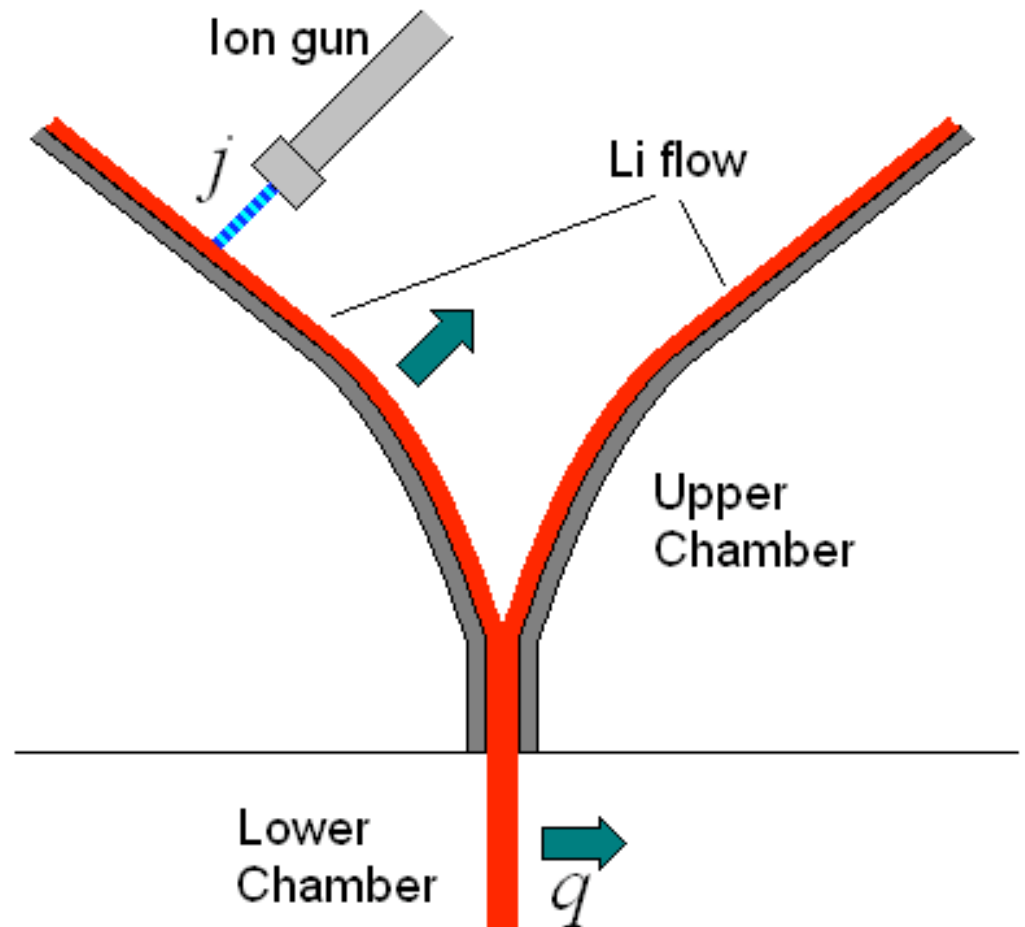- IIAX – Matt Coventry
- Modeling Efforts – David Ruzic
- Conclusion

PLASMA MATERIAL
INTERACTION GROUP
University of Illinois at Urbana-Champaign

Retention measurement in FLIRE

- A direct measurement is the retention coefficient:

$$R = \frac{q}{j}$$

q: release rate in the lower chamber

j: injection rate in the upper chamber

Ion gun

j

Li flow

Upper Chamber

Lower Chamber

q

Criticism of FLIRE

- In particular, the statement "the (He) neutral pressure in the upper chamber does not affect the (He) signal in the lower chamber" needs further validation.

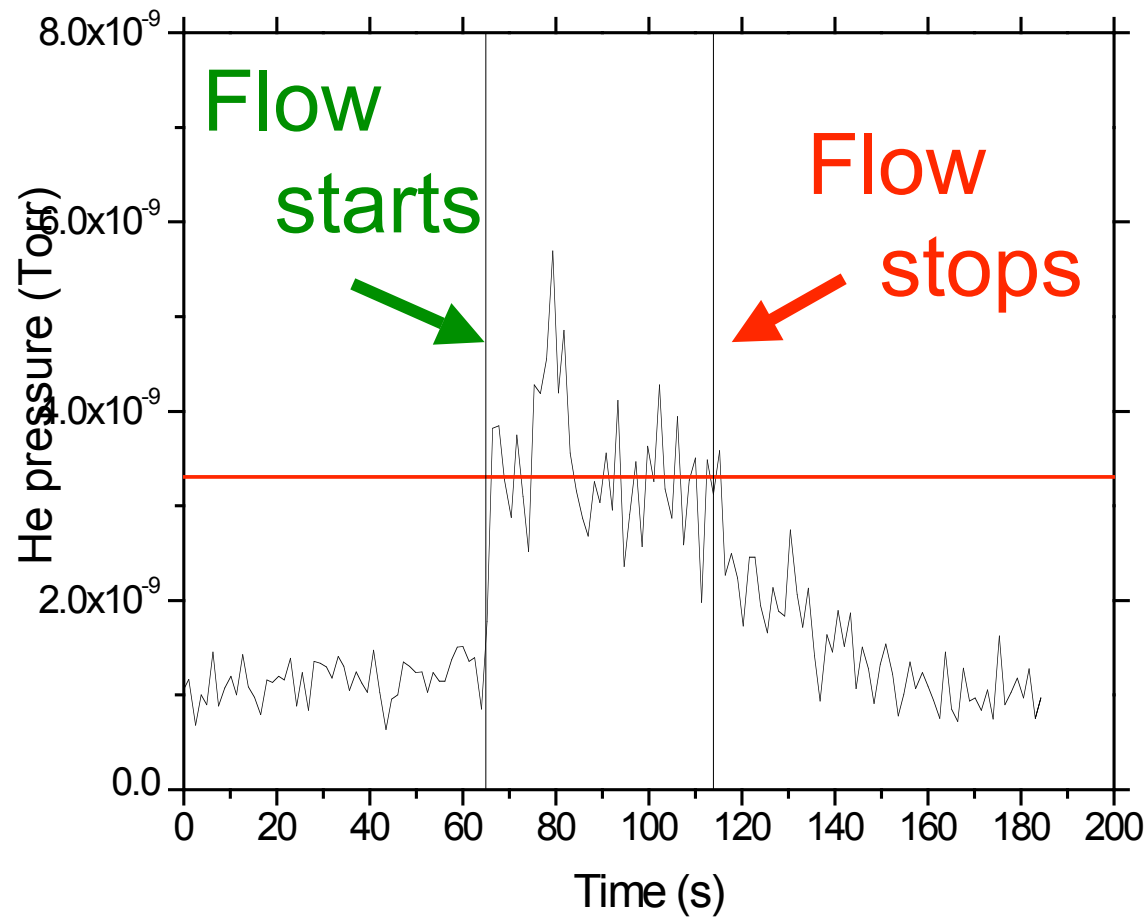 *(from reviewer of this year's DOE proposal)*

No implantation case

- Upper chamber filled to 2×10^{-5} Torr He (typical operating pressure)
- Flow velocity 70 cm/s
- Temperature 230 °C
- Ion source not turned on
- Flow lasts 45 seconds
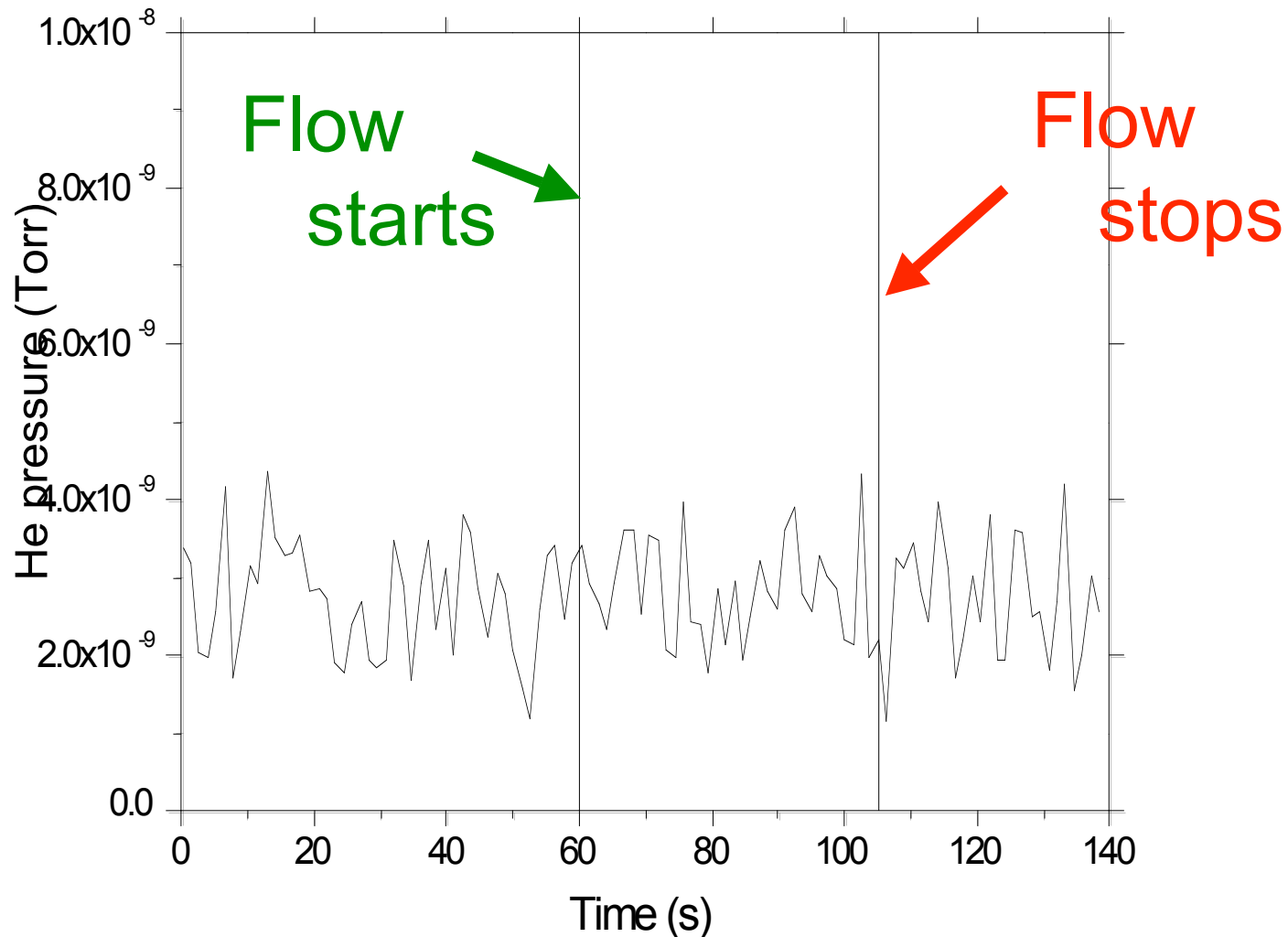
Pressure does **not** rise if the ion gun is off even though there is a significant D_2 pressure in the upper chamber !

Implantation case

- Upper chamber filled to 2×10^{-5} Torr He (typical operating pressure)
- Flow velocity 70 cm/s
- Temperature 230 °C
- **2 keV, 1.8 µA ion beam**
- Flow lasts 45 seconds

PLASMA
MATERIAL
INTERACTION GROUP
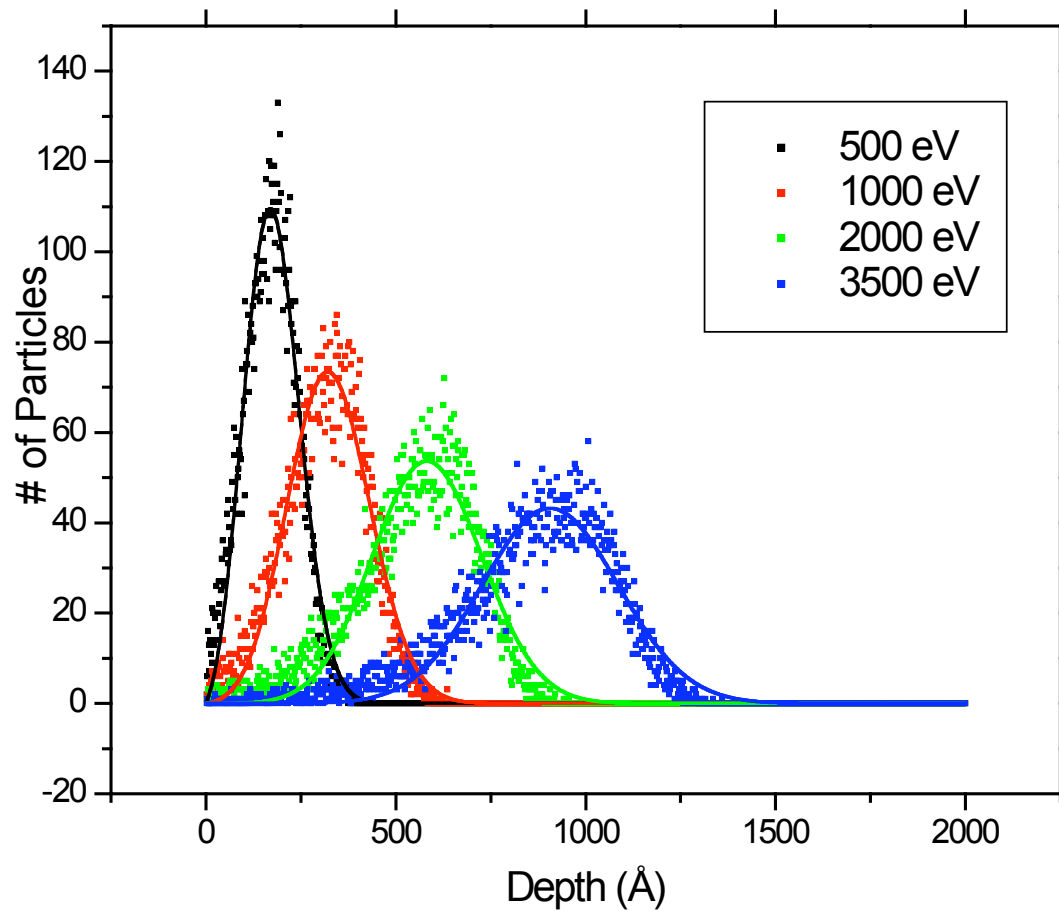University of Illinois at Urbana-Champaign

Pressure rises only when the ion gun is on in the upper chamber

Criticisms of FLIRE

- Although this experiment has been in operation for several years, the measurements have large error bars and display time dependent effects that have yet to be understood.

  (from reviewer of this year's DOE proposal)

PLASMA
MATERIAL
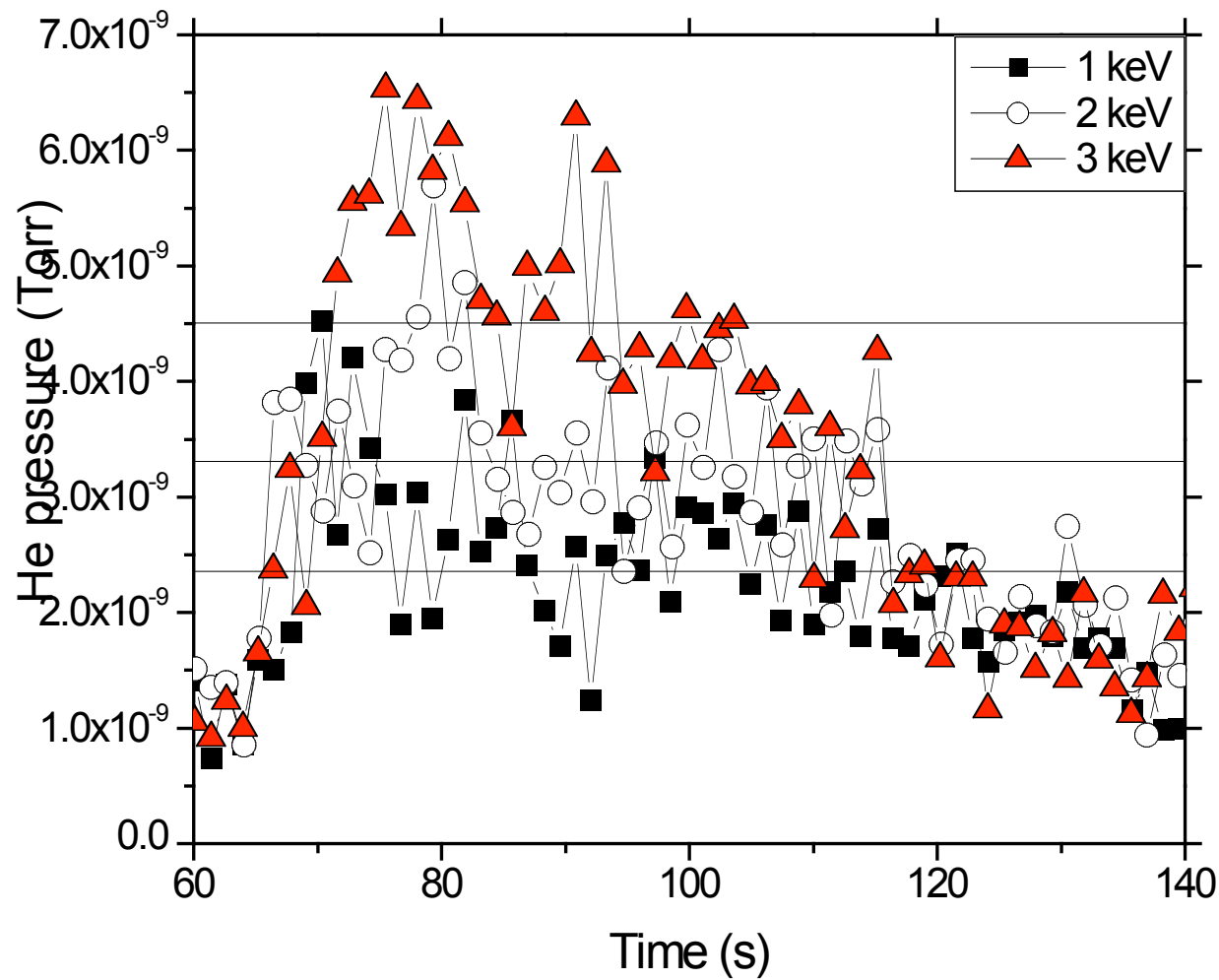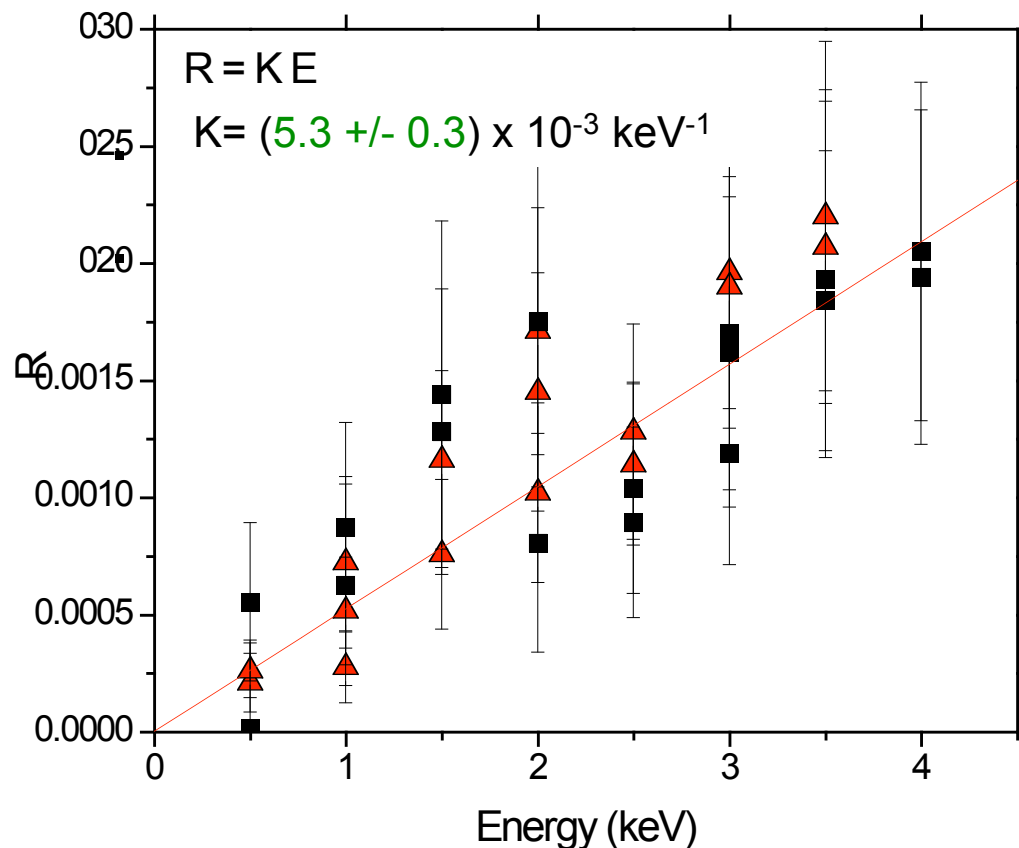**INTERACTION GROUP**
University of Illinois at Urbana-Champaign

Range of He ions in Li

TRIM simulation

Shows approximately linear behavior

$$r = (2.5\text{x}10^{-6}\ \text{cm/keV})E$$

PLASMA MATERIAL
INTERACTION GROUP
University of Illinois at Urbana-Champaign

Pressure traces, set B

Retention results

R = K E

K = (5.3 +/- 0.3) x 10^{-3} keV^{-1}

- Taking into account currents, and flow velocity one relation can be found
- Overall error in the retention relation is **less than 6%**

Criticisms of FLIRE

- Pooling of the Li before it enters the next chamber mixes the layer which absorbed the He and therefore makes diffusion coefficient calculations more difficult.

(paraphrased comments from October conference call)

Valid point – but shows results are a lower limit

- Pooling – would cause the He to be buried deeper under the surface and therefore it would not all be able to come out in the lower chamber.

- However, we see an immediate release in the lower chamber whenever the gun comes on. Maybe the release should be larger than the one observed.

- Great! It means maybe even more is retained. Therefore we established a lower limit on retention. Perhaps it is even greater than 5% for 10 keV ions

- Pooling will occur in any realistic divertor configuration as well.

Is this enough retention for a reactor ?

- For E = 10 keV, R = 0.053
- We had 0.44 m/s over a 0.1 m distance
- Approximately 0.25 seconds of exposure and opportunity for prompt release.
- Same as 20 m/s over 5 m – a realistic reactor scenario

At least 5% of the He would be pumped